# Early Supplies of Available Nitrogen to the Seed-Row as Affected by Fertilizer Placement

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Abstract

A field experiment was conducted at Star City, (legal location SW6-45-16-W2); Saskatchewan, Canada from May to June 2000, to measure N and P supply rates from fertilizer band to canola seed row. Ion exchange resin membrane probes (PRS™) were used to measure nutrient supply rates in four treatments (80 kg/ha of urea side-band, 80 kg/ha of urea mid-row band, check/no N (side-row)/P side-banded, check/no N (mid-row)/P seed placed. The treatments were arranged in a randomized complete block design with four replications. Two anion and cation exchange resin probes (PRS™) were placed in each plot in the seed-row immediately after seeding and fertilizing. The probes were allowed to remain in the field for 2 days and replaced with another set of probes every 4 days for a total of 14 days until canola emerged. Ammonium-N, nitrate-N and P supply rates were calculated based on the ion accumulated on the probes. Grain and straw yield were measured in each plot. Urea side-row band treatments had significantly higher cumulative available N supply rates than mid-row banded placement. No significant differences were observed in P supply rates. The higher N rates (120 kg N/ha) showed lower grain yield in side banding than mid-row banding treatment possibly due to seedling damage, however the earlier fluxes of N into the seed-row observed with side-banding may be an advantage at lower N rates in N deficient soils.

## Introduction

The adoption of direct seeding systems had a major impact on reducing soil erosion and fuel consumption on the Prairies. Direct seeding usually involves placement of all fertilizer nutrients during the seeding operation. Seed-placed application of large amounts of fertilizer is not an option due to potential seedling damage. Therefore manufacturers have developed opener systems to separate seed and fertilizer. These systems include side-banding and mid-row banding. Although research has investigated the performance of side-banding openers, there has been limited information on comparisons between side-row banding and mid-row banding of N fertilizer in direct seed systems. Therefore, the objectives of this study were to measure N and P supply rates from the fertilizer band to canola seed–row, to determine the positional effect on N and P availability to canola, and to compare the effect of N placement on canola seed and straw yield.

**Methodology**

Study Site Description

The field experiment was conducted at Star City, Saskatchewan, Canada. The soil at this site was classified as the Northern Light-Tiger Hills Association (NLTH), described as a mixture of Gray (Northern Light) and Dark Gray (Tiger Hills) soils formed in shallow, silty lacustrine materials underlain by glacial till that usually have clay loam surface textures (Saskatchewan Soil Survey, 1989). The surface soil (0-30 cm) is non-saline, slightly stony and has low susceptibility to wind and water erosion. (Table1).

The soils were air dried, crushed, passed through 2-mm sieve, and stored at room temperature. Texture was determined by the pipette method (Gee and Bauder, 1986). Electrical conductivity (EC) and pH were measured using a 1:1 soil:water suspension (Janzen, 1993, Hendershot et al., 1993). Organic carbon was measured by dry combustion method using Leco carbon analyzer (LECO©Corporation, 1987). The inorganic N was measured in 2M KCl extracts (Keeney and Nelson, 1982). The amount of available P was determined by a modified Kelowna method (Qian et al., 1994).

Table 1. Physico-chemical Characteristics of the Soil at the Star City Site.

| Soil Association | Texture | pH | EC $S/m^{-1}$ | Organic C % | $NO_3$-N (μg/g) | $NH_4$-N (μg/g) | Extractable P (μg/g) |
|---|---|---|---|---|---|---|---|
| NLTH | Clay loam | 7.2 | 0.2 | 1.5 | 4.3 | 2.9 | 1.9 |

Experimental Design

Treatments included 80 kg/ha urea N side-band/P side-band, N mid-row banded/P seed placed, Check-no N fertilizer (side-row band)/P side-band, Check-no N fertilizer (mid-row band)/P seed placed and were arranged in a randomized complete block design in four replications. The main field trial was conducted with 3 fertilizer rates (40,80,120 kg/ha) and two fertilizer forms (urea and anhydrous ammonia) to compare the effect of the N placement method (side-banded vs. mid-row banded) on crop recovery of N, yield and protein content.

Two anion and two cation exchange resin membrane probes (PRS™) were placed in each plot immediately after seeding and fertilizing. The PRS™ probes were inserted into the seed row on May 20, 2000 and allowed to remain in the field for 2 days and replaced with another set of probes in the same slot. Burial time in the field initially was 2 days followed by three successive 4-day periods for a total of 14 days. The probes were inserted immediately in the same slot as the previous probes, allowing a cumulative nutrient supply to be recorded until the canola seedlings emerged. The probe area was kept free of plant growth for the duration of measurement and the seed was removed from row before burial. Weeds were removed by hand picking. Gravimetric moisture content was measured over the study period to determine the relationship between field moisture content and the nutrient supply rates. After the probe was removed and washed free of adhering soil, the probes were eluted in 0.5 M HCl for an hour, to desorb the nutrient ions from anion and cation resin surface into HCL solution. The concentrations of N (ammonium and

nitrate) and P in the extracts were determined by colorimetry using Technicon Autoanalyzer II (Industrial method no. 100-70W).
Statistical Analysis

The experimental design was a randomized complete block design (RCBD) with four replicates. The analysis of variance (ANOVA) was performed using the General Linear Model procedure of the Statistical Analysis System package (SAS Institute Inc. Cary, 1998). Fisher's Protected Least Significant Difference (LSD) test was used to compare treatments means.

## Results and Discussion

<u>Ammonium and Nitrate Supply Rates</u>
Mean ammonium and nitrate supply rates as measured by ion exchange probes at Star City are presented in Table 2. Urea side-row banded treatment showed a significantly higher ammonium supply rate to the seed row at 2 days, 6 days, 10 days and 14 days after seeding. Significantly higher nitrate supply rates were observed for side-banding 2$^{nd}$, 3$^{rd}$ and final burial period. No significant difference was evident among check plots.

**Table 2.** Mean Ammonium and Nitrate Supply Rates over Time.

| Treatment | Ammonium supply rate (μg N/10cm$^2$) | | | | Nitrate supply rate(μg N/10cm$^2$) | | | |
|---|---|---|---|---|---|---|---|---|
| | 2 days | 6 days | 10days | 14 days | 2 days | 6 days | 10days | 14days |
| Urea side-row banded | 43.4 | 54.9 | 63.7 | 63.5 | 68.1 | 160.6 | 139.1 | 68.1 |
| Urea mid-row banded | 9.5 | 3.1 | 1.6 | 5.2 | 52.6 | 86.1 | 63.5 | 27.5 |
| Check(side-row) | 7.8 | 6.8 | 3.6 | 1.7 | 32.9 | 84.5 | 28.8 | 14.6 |
| Check(mid- row) | 14.0 | 2.8 | 4.4 | 6.7 | 19.4 | 24.6 | 35.6 | 17.8 |
| LSD (0.05) N=16 | 27.8 | 25.9 | 24.5 | 26.7 | 25.8 | 65.2 | 51.3 | 20.8 |

Means followed by same letter are not significantly different ($p \leq 0.05$).

Cumulative ammonium and nitrate supply rates over the 14-day period were calculated by summing the amounts of ammonium and nitrate sorbed on the probes during the individual burial periods (Figure 1). Not unexpected, the urea side-row banded treatment, which places fertilizer close to the seed, had significantly higher ammonium and nitrate supply rates than did the urea mid-row banded treatment.

Urea is rapidly hydrolyzed to ammonium in the soil by urease enzymes and after several days is largely converted to nitrate anions by nitrifying organisms. The ammonium cation, which can adsorb to negatively charged soil colloids is less mobile than nitrate which explains the lower ammonium supply rates from the more distant mid-row band compared to the closer side-row banded fertilizer placements. Most of the nitrogen reached the seed from the mid-row band in the nitrate form.

Phosphorus Uptake

Phosphorus is absorbed by plants as primary and secondary orthophosphate ions ($H_2PO_4^-$ and $HPO_4^{2-}$) which exist in the soil solution and are replenished from exchangeable and labile forms of soil P (Barber 1984). Prairie soils are high in total P, but inherently low in the proportion available for plants. The mean P supply rate was not significantly affected by treatments over the period (Table 3). Under dry conditions, crop uptake of P fertilizer is limited due to low diffusive flux. No significant difference was observed in P supply rates between P side-banded and P seed-placed.

**Table 3**. Mean Phosphorus Supply Rates over Time

| **Treatment** | **P-supply rate (µg P/10cm$^2$)** | | | |
|---|---|---|---|---|
| | **2 days** | **6 days** | **10days** | **14 days** |
| Side-row banded N/ P side-banded | 4.7 | 5.5 | 3.9 | 1.3 |
| Mid-row banded N/ P seed placed | 4.2 | 4.7 | 2.9 | 1.2 |
| Check (side-row/ no N)/ P side-banded | 1.9 | 4.5 | 2.4 | 1.0 |
| Check (mid-row/ no N)/ P seed placed | 1.6 | 3.5 | 2.2 | 0.7 |
| | NS | NS | NS | NS |

NS= non significant at the P=0.05 level.

Effects of N Fertilizer Rates on Canola Seed Yield

At the Star City site, the urea side-banded treatment at high N rates resulted in lower seed yield than urea mid-row banded treatment (Table 4). However, the urea side-row band treatment at low N rates tended to have higher yield than mid-row banded treatment. This is similar to results reported by Grant et al. (1999) in which, urea side- row banded treatments had significantly lower canola yield at high rates of N and the effects were greater on dry, coarse-textured soils than in silty clay soils. In this study, urea side-row band treatment at low rates had higher yield than mid-row banding. This may be due to early N supply from the fertilizer band to seed. However, higher N fertilizer rates showed lower yields in side banded treatment and may reflect seedling damage.

**Table 4.** Canola Seed Yield at Star City.

| Treatment | **Nitrogen rates (Kg/ha)** | | | |
|---|---|---|---|---|
| | **0** | **40** | **80** | **120** |
| **Urea side-band** | 1703 | 2353 | 2290 | 2252 |
| **Urea mid-row band** | 2075 | 2158 | 1989 | 2604 |

LSD (0.05) = 305

**Conclusions**

Side row banding places the fertilizer nutrient closer to the seed row than mid-row banding. Not surprisingly, we found early N supply was significantly greater in side than mid row banded fertilizer placement. Side-banding tended to have higher yield at low N rates than mid-row banding, but mid-row banding appeared to produce higher yield at higher N rates probably due to better seed and fertilizer separation resulting in less seedling damage.

This study only examined nutrient supply rates until the time of plant emergence. As well, the study includes only a limited number of treatments and one growing season, which limits the scope of interpretation. Future studies on the effect of fertilizer placement on nutrient movement should include different types of fertilizer, soil types and climatic conditions.

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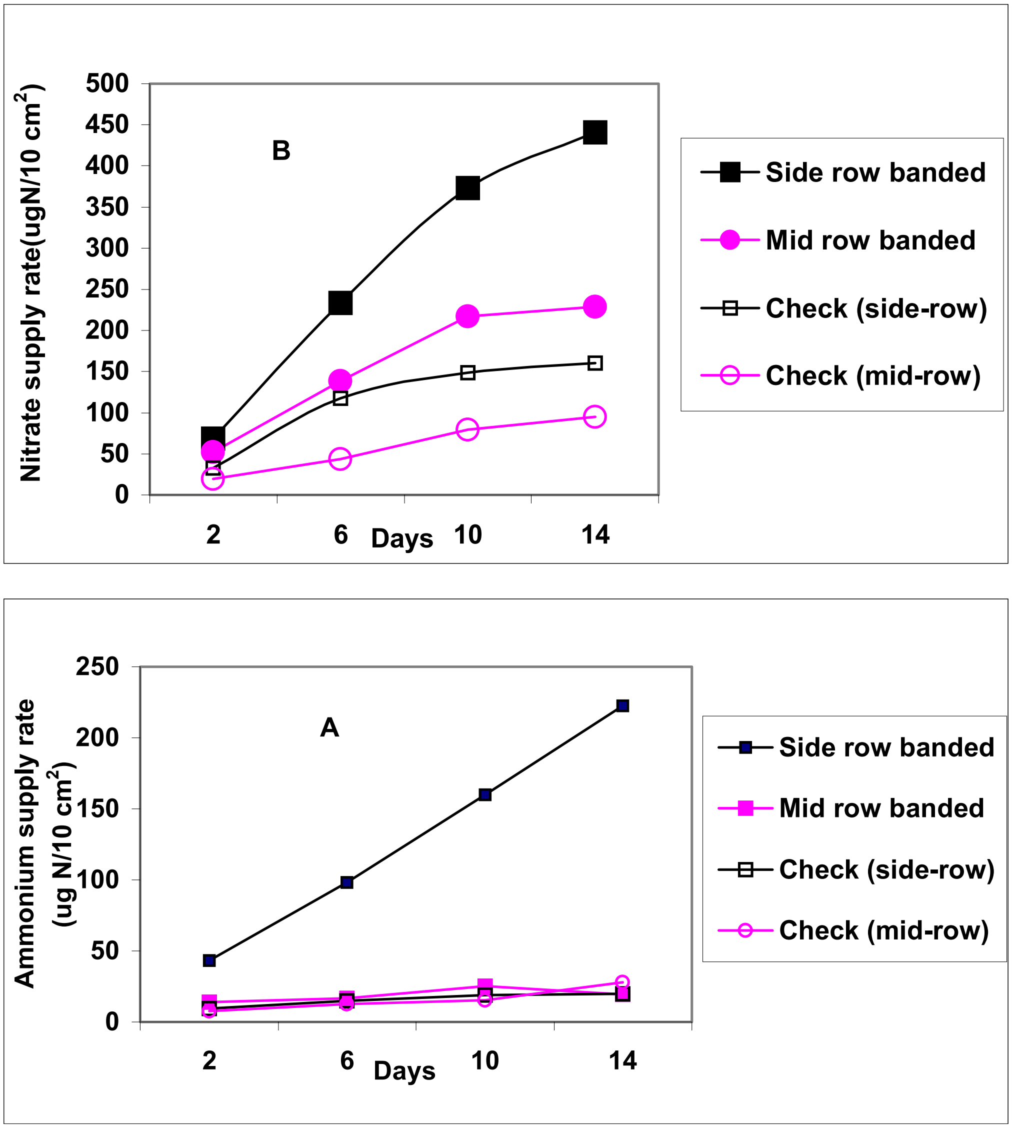


**Figure 1.** Cumulative ammonium (A) and nitrate (B) supply rates to the seed-row over time.